EP35610(2)

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H05B 6/80 — A1

(11) International Publication Number: WO 98/35533

(43) International Publication Date: 13 August 1998 (13.08.98)

(21) International Application Number: PCT/EP98/00553

(22) International Filing Date: 3 February 1998 (03.02.98)

(30) Priority Data:
9700448-5 10 February 1997 (10.02.97) SE

(71) Applicant *(for all designated States except US)*: WHIRLPOOL CORPORATION [US/US]; 2000 M 63, Benton Harbor, MI 49022 (US).

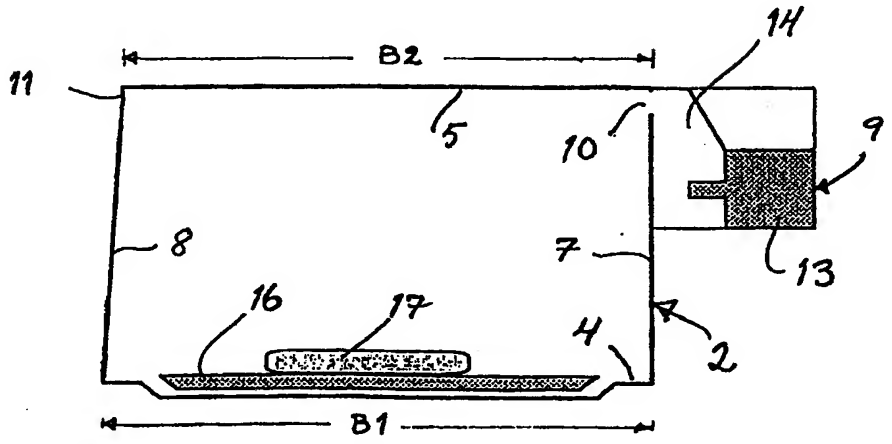
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: RISMAN, P., O. [SE/SE]; Sandsjön 4480, S-438 92 Härryda (SE). CARLSSON, Dan [SE/SE]; Skepparegatan 37B, S-602 27 Norrköping (SE).

(74) Agent: GUERCI, Alessandro; Whirlpool Europe S.r.l., Viale G. Borghi, 27, I-21025 Comerio (IT).

(81) Designated States: AU, BR, CN, JP, KR, SK, TR, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: MICROWAVE OVEN



(57) Abstract

A microwave oven and a method for feeding microwaves into it. The rectangularly parallelepipedal oven cavity (2) has a side wall (8) with a slight inward slope which gives an upwardly decreasing horizontal cross section. By the selection of a suitable slope the mode balance in the cavity is affected so that the best equalisation of the heating pattern is obtained.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

NSDOCID: <WO_____9835533A1_I_>

MICROWAVE OVEN

Field of the Invention

The present invention relates to a microwave oven and feeding of the same with microwaves.

Technical Background

Microwave ovens for domestic use and the like are usually made with an essentially rectangularly parallelepipedal cavity. This is due to both manufacturing considerations and a conventional view of what microwave ovens should look like. Although it is possible to a certain extent to calculate which so-called cavity modes are obtained in a rectangularly parallelepipedal cavity, it has proved difficult to achieve a reasonably symmetrical heating pattern in such a cavity, in particular when it is fed sideways. So-called field stirrers or rotating bottom plates for the load are often employed with a view to improving the heating pattern.

In similar contexts, such as tunnel furnaces for industrial microwave heating, vertical cross-section geometries (across the direction of transportation through the furnace) other than rectangular ones have been used. In this connection, it has been considered that the action of the walls can be interpreted on the analogy of optical reflection, that is, one conceives of being able to obtain optical-geometrical control of the distribution of the microwaves.

An example of such a configuration of microwave ovens where "microwave reflection" is considered to be employed is disclosed in EP 0 268 379 B1.

Objects of the Invention

An object of the present invention is to make possible an improved heating pattern in a rectangularly parallelepipedal cavity in a microwave oven.

Another object of the invention is to make possible such an improved heating pattern without employing moving parts, such as field stirrers or rotating bottom plates.

A further object of the invention is to provide a method which allows improved configuration of a rectangularly parallelepipedal cavity with respect to the resulting heating pattern.

Summary of the Invention

The above-mentioned objects are achieved by a microwave oven and methods which exhibit the features stated in the appended claims.

The basis of the invention is thus that, surprisingly, it has been found that the heating pattern in a rectangularly parallelepipedal oven cavity can be advantageously affected by the arrangement of a non-constant horizontal cross-section in the cavity. In this connection, the cross-section changes concerned do not change the general rectangularly parallelepipedal shape and cannot be compared to wall embossing, rounding of corners, etc. which are conventionally done in order to adjust the rectangularly parallelepipedal dimensions for manufacturing reasons and generally to facilitate the manufacture of the cavity and improve mechanical stability.

We have found that the approach to reflection described above lacks relevance in the case of smaller cavities of the kind which exist in microwave ovens for domestic use.

The invention is thus based on the insight that the relative phase and amplitude of the modes in the cavity can be modified favourably in and for heating pattern levelling-out or equalisation by means of well-judged, relatively modest vertical changes to the horizontal cross-section of the cavity. Put another way, by making these kinds of cross-section changes, one can control the mode balance with respect to both relative amplitudes and phase of the modes involved so that a more even heating pattern is achieved.

We have found that if the cross-section modifications according to the invention are kept relatively small and preferably with a slow vertical change, characterisable cavity volume modes are maintained while the heating pattern is changed. The changes can be observed experimentally, which provides an opportunity for adjustments in order to achieve the best heating pattern.

In experimental tests, when the cross-section change is varied in small steps, it has been found to be possible to follow the heating pattern changes continuously, which, as will be appreciated, provides very good optimisation conditions.

According to the invention it is preferable to employ a horizontal cross-section change vertically, which means that the horizontal cross-section decreases upwards at least in the upper part of the cavity. Advantageously, the cross-section change can be achieved by a cavity side wall being made at least partly inward sloping.

Thus, according to a first aspect of the invention, a method is provided for microwave feeding of a rectangularly parallelepipedal microwave oven cavity, which means that in and for equalisation of the effect of the microwaves in the cavity, the mode balance of the microwave field is affected by the cavity being given, in relation to the horizontal cavity bottom cross-section, at least in the upper part of the cavity an upwardly decreasing horizontal cross-section. In this connection, it is preferred to achieve the decreasing horizontal cross-section by sloping inwards at least the upper part of a cavity side wall. The feeding of microwaves is advantageously done through an opening in a cavity side wall opposing the inward sloping wall, the microwave feeding preferably taking place along an area closely adjacent to the cavity ceiling.

Alternatively, it is also possible to feed microwaves through an opening in the cavity ceiling, also in

this case suitably extended in a direction parallel to the sloping side wall.

According to a second aspect of the invention, a method is provided for acting on the heating pattern, which is obtained by means of microwaves fed into an rectangularly parallelepipedal microwave oven cavity, changes to the heating pattern being achieved by a cavity side wall being caused to slope inwards at least in its upper part, so that the cavity has an upwardly decreasing horizontal cross-section in relation to the available bottom cross-section of the cavity. In this connection, it is possible on the basis of a chosen cavity width to vary the horizontal cross-section change by changing the degree and/or extent of the inward slope of the cavity wall and observing the resulting changes to the heating pattern. It will be appreciated that by carrying out such changes of the inward slope of the side wall for a number of different cavity widths, it is possible to determine the cavity width and side wall inward slope combination which provides the best heating pattern.

In this connection, it should be mentioned that it has been found that the inventive effect on the heating pattern is particularly pronounced for certain cavity widths.

According to a third aspect of the invention, a microwave oven is provided, comprising a rectangularly parallelepipedal cavity and a microwave source connected thereto for feeding microwaves into the cavity, the cavity, in relation to its available bottom cross-section, having an upwardly decreasing horizontal cross-section at least in the upper part of the cavity. In this connection, the cavity preferably has a side wall, which at least partly slopes inwards in order to provide the desired horizontal cross-section decrease. Advantageously, the inward slope is in the upper part of the side wall, while the lower part of the side wall is vertical and preferably at least 50 mm high. The inward slope of

the upper part of the side wall does not need to extend all the way up to the cavity ceiling, rather the side wall can have a short vertical ceiling connection part terminating at the top. Although, preferably, the sloping side wall part is plane, other configurations are also possible. The slope of the side wall is preferably over essentially the whole actual wall width and advantageously over at least about half the wall height.

For manufacturing reasons, the slope of the side wall can be made within a deep-drawn portion of the side wall, so that the joining with the back wall and the front of the oven can be done with vertical joints. In this case, the slope can advantageously be over about 85% of the total depth of the cavity.

A microwave oven according to the invention suitably has a horizontal cross-section which is approximately square. The "depth" is preferably between about 85% and about 120% of the "width". For a microwave oven for conventional domestic use (with a microwave frequency of 2450 MHz) is has been found that the following two dimensionings are particularly advantageous:

1) Horizontal cross-section width at the top between about 315 mm and about 335 mm, preferably about 325 mm. Available bottom cross-section width between about 8 mm and about 15 mm larger.
2) Horizontal cross-section width at the top between about 385 mm and about 410 mm, the available bottom cross-section width being between about 8 mm and about 15 mm larger.

In both cases, the height of the cavity from the bottom plate or the cavity bottom to the cavity ceiling is from about 160 mm to about 230 mm.

The invention affords a number of advantages:

An even and essentially coldspot-free heating pattern;

Improved symmetry right-left in the heating pattern in a cavity fed from the side, in particular in an oven without moving parts;

A wider oven at the bottom;
A more "space-efficient" oven;
Greater freedom in the choice of cavity dimensions;
A further degree of freedom for configuration adjustments; and
Greater freedom in the choice of the location of the microwave feeding.

The invention will be described in more detail below by way of embodiments with reference to the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a schematic perspective view of an embodiment of a microwave oven according to the invention.

Fig. 2 schematically shows a vertical cross-section through the middle of the oven in Fig. 1.

Fig. 3 schematically shows a vertical cross-section of the same kind as in Fig. 1 through another embodiment of a microwave oven according to the invention.

Description of Embodiments

The embodiment of a microwave oven according to the invention illustrated in Figs 1 and 2 comprises an outer casing 1 which is outlined only and an oven cavity 2, which is closed by means of a front door 3. The cavity 2 is formed by a horizontal cavity bottom 4, a horizontal cavity ceiling 5, a vertical back cavity wall 6, a front vertical wall on the inside of the front door 3 and two cavity side walls 7 and 8. The right side wall 7 in Figs 1 and 2 is vertical and provided with a microwave unit for feeding microwaves into the oven cavity through a slot-shaped, rectangular side wall opening 10, such as will be described in more detail below. The left side wall 8 in Figs 1 and 2 slopes inward somewhat and thus forms an angle of about 3° to vertical. Consequently, the cavity is rectangularly parallelepipedal except for the inward slope of the side wall 8. However, the inward slope is so small that it cannot be considered that there is any essential deviation from the rectangularly paral-

lelepipedal shape, except for the resulting microwave characteristics.

All the cavity defining wall surfaces in this embodiment are generally plane, although the sloping side wall 8 joins the cavity ceiling at the top with a vertical wall part 11 of a small height.

It will be appreciated that in the example shown the horizontal cross-section of the oven cavity will gradually decrease upwards by the horizontal cross-section width decreasing upwards from the available bottom width B1 to the ceiling width B2. It will be appreciated that the horizontal cross-section in depth is constant.

The microwave unit 9 comprises in a manner known per se a magnetron 13 and a waveguide device 14 connected thereto for feeding microwaves into the cavity through the feeder slot 10. As was mentioned above, this slot is usually elongated and rectangular and arranged at the top and in the midpoint on the side wall 7 in the connection area to the cavity ceiling 5.

As will seen from Fig. 2, the oven can comprise a microwave-transparent bottom plate 16 for a foodstuff load 17. If desired, this plate can be rotatable. However, it has been found that the oven constructed according to the invention despite the sideways feeding of microwaves gives a heating pattern which is so even that a rotating bottom plate cannot be considered necessary.

Examples of typical dimensions for an oven for domestic use according to Figs 1 and 2 are B1 - about 333 mm, B2 - about 325 mm; cavity height (over the bottom plate) - about 185 mm; and cavity depth - about 370 mm.

Fig. 3 shows a schematic vertical cross-section of the same kind as in Fig. 2, which illustrates another embodiment of an oven according to the invention. The latter differs from the oven according to Figs 1 and 2 with respect to the design of the sloping side wall and the microwave feeding.

In this example, the sloping side wall 8′ in Fig. 2 has a lower part 21, which is vertical, and an upper inward-sloping part 22. The inward slope begins about halfway up the side wall and amounts to about 6°. The horizontal cross-section decrease adjacent to the cavity ceiling is here somewhat larger than in the oven according to Figs 1 and 2, typically about 10 mm.

In Fig. 3 the microwave feeding is done through a rectangular ceiling slot 10′, which is centrally located in the cavity ceiling 5 and whose long side is parallel to the cavity side walls 7 and 8′ and which is fed by the intermediary of a waveguide device 14′ arranged on the cavity ceiling.

As the skilled person will appreciate, the invention is not limited to the examples shown, and modifications are possible within the scope of the appended claims. For example, it is possible to divide up the side wall slope between the two opposing side walls.

CLAIMS

1. A method for microwave feeding of a rectangularly parallelepipedal microwave oven cavity, characterised in that in and for equalisation of the effect of the microwaves in the cavity, the mode balance of the microwave field is affected by the cavity being given, in relation to the horizontal cavity bottom cross-section, an upwardly decreasing horizontal cross-section at least in the upper part of the cavity.

2. A method according to claim 1, characterised in that the decreasing horizontal cross-section is achieved by at least the upper part of a cavity side wall being sloped inwards.

3. A method according to claim 2, characterised in that microwaves are fed into the cavity through at least one opening located at the top in a cavity side wall opposing the inward sloping side wall.

4. A method according to claim 2 or 3, characterised in that microwaves are fed into the cavity through an opening in the cavity ceiling.

5. A method for affecting the heating pattern which is obtained by means of microwaves fed into a rectangularly parallelepipedal microwave oven cavity, characterised in that displacements in the heating pattern are achieved by a cavity side wall being given an inward slope at least in its upper part, so that the cavity has an upwardly decreasing horizontal cross-section.

6. A method according to claim 5, characterised in that on the basis of a chosen cavity width the horizontal cross-section change is varied by the degree and/or extent of the inward slope of the side wall being changed and the resulting changes to the heating pattern being observed.

7. A method according to claim 6, c h a r a c - t e r i s e d in that changes to the inward slope of the side wall are carried out for a number of different cavity widths in and for determination of the cavity width and side wall inward slope combination which provides the best heating pattern.

8. A microwave oven comprising a rectangularly parallelepipedal cavity and a microwave source for feeding microwaves into the cavity connected thereto, c h a r a c t e r i s e d in that the cavity has, in relation to its bottom cross-section, an upwardly decreasing horizontal cross-section at least in the upper part of the cavity.

9. A microwave oven according to claim 8, c h a r a c t e r i s e d in that a cavity side wall slopes inwards at least at the top.

10. A microwave oven according to claim 9, c h a r a c t e r i s e d in that said side wall has a vertical lower part, which preferably is at least about 50 mm high.

11. A microwave oven according to claim 9 or 10, c h a r a c t e r i s e d in that a cavity side wall which opposes said sloping slide wall is provided with at least one slot opening for the feeding of microwaves located at the top.

12. A microwave oven according to any one of claims 8-11, c h a r a c t e r i s e d in that it is provided with a slot opening in the cavity ceiling for the feeding of microwaves, the slot opening extending transversely of a vertical plane, in which the horizontal cavity width decreases upwards.

13. A microwave oven according to any one of claims 8-12, c h a r a c t e r i s e d in that the horizontal cross-section of the cavity has a depth which is from about 85% to about 120% of the width.

14. A microwave oven according to any one of claims 8-13, c h a r a c t e r i s e d in that cross-section

width at the top of the cavity is in the interval from about 315 mm to about 335 mm, and that the cross-section width is from about 8 to about 15 mm larger at the bottom.

15. A microwave oven according to any one of claims 8-13, characterised in that the cross-section width at the top of the cavity is in the interval from about 385 mm to about 410 mm, and that the cross-section width is from about 8 to about 15 mm larger at the bottom.

16. A microwave oven according to claim 14 or 15, characterised in that the cavity has a height of from about 150 mm to about 220 mm.

17. A microwave oven according to any one of claims 10-16, in combination with claim 9, characterised in that the sloping area of the side wall has a height of at least about 50 mm.

Fig.1

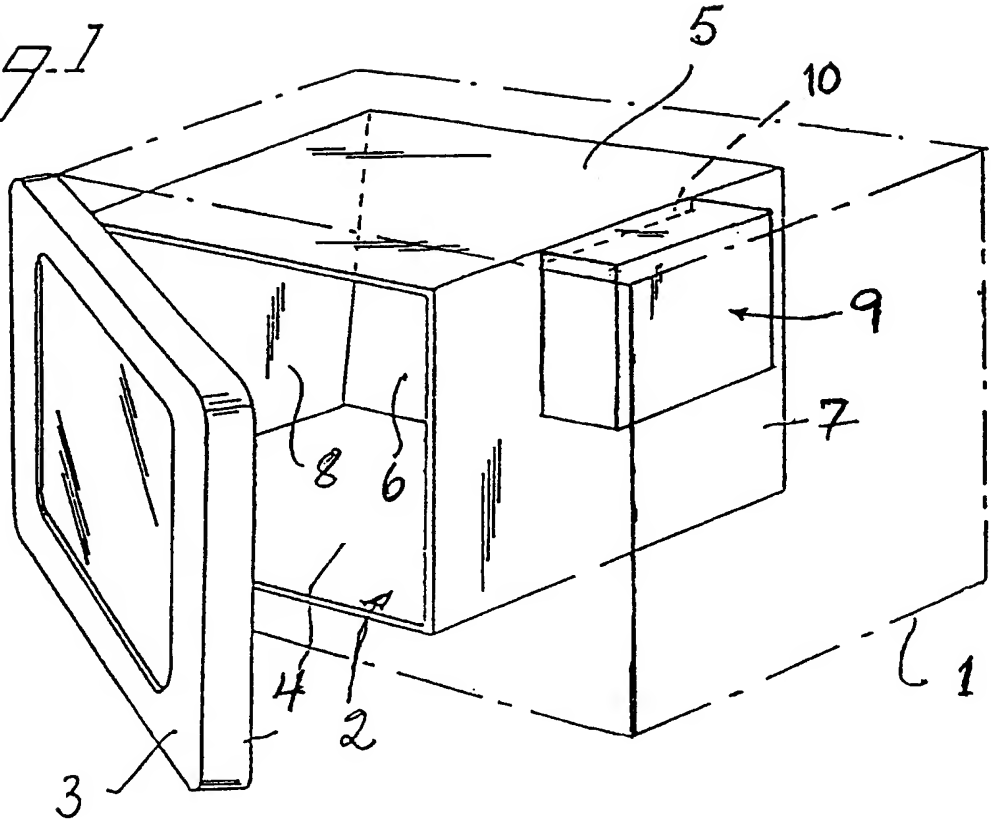


Fig.2

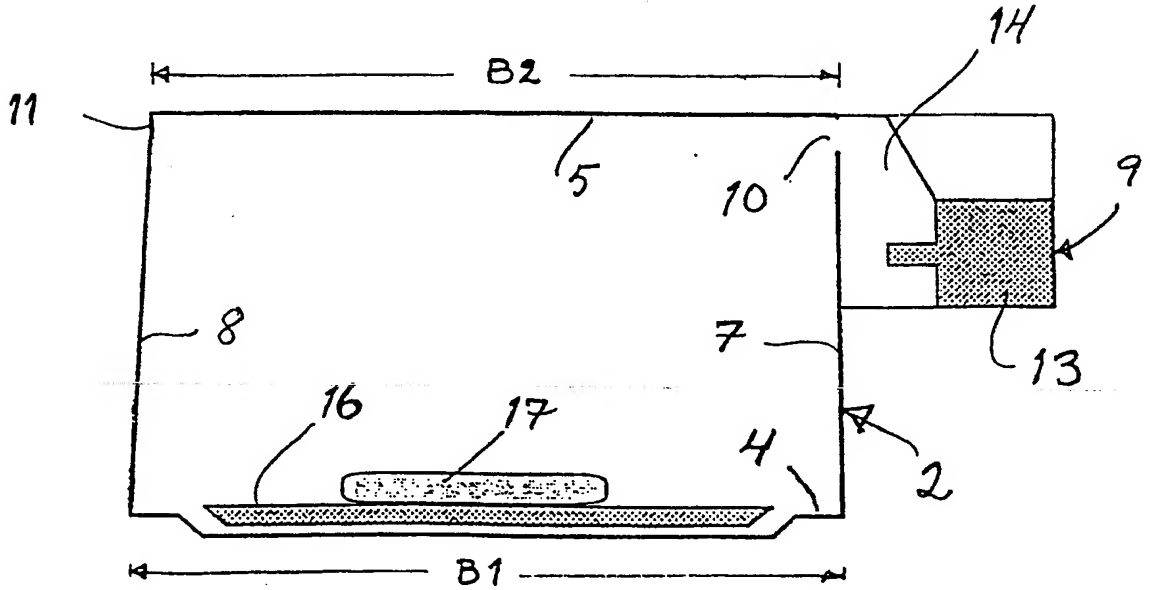
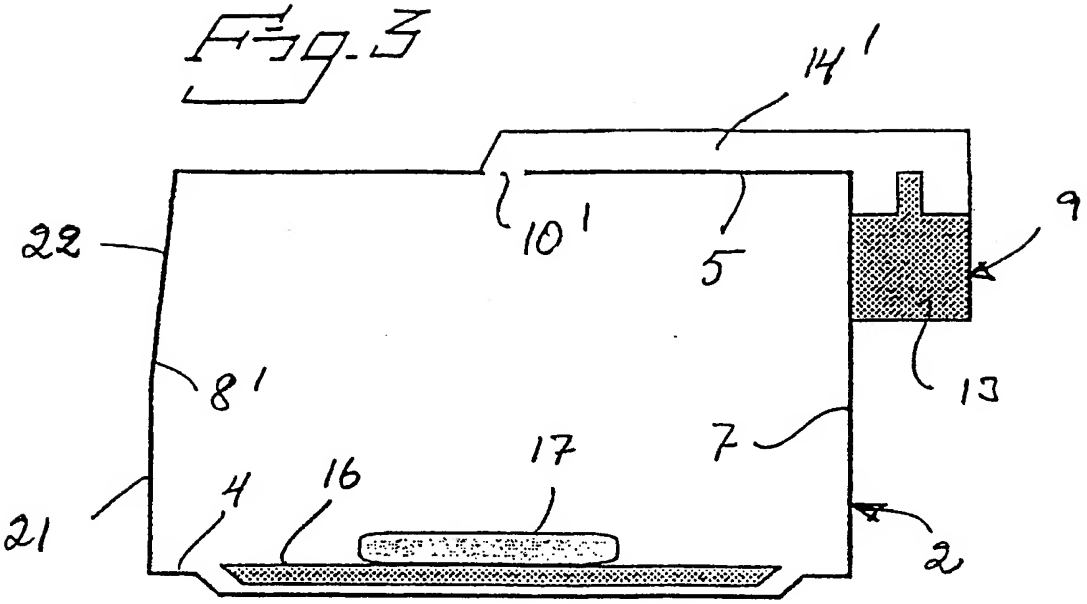


Fig. 3



INTERNATIONAL SEARCH REPORT

Inter. .onal Application No
PCT/EP 98/00553

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05B6/80

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 814 708 A (RAYTHEON MFG. CO.) 26 November 1957 see column 3, line 11 - line 15	1,2,5
X	US 3 991 295 A (AKIYOSHI MITSUO) 9 November 1976 see column 5, line 63 - column 6, line 1	1
X	DE 15 15 149 A (SIEMENS-ELECTROGERÄTE GMBH.) 14 August 1969 see claim 1	1
P,X	WO 97 44988 A (IMPLICO BV ;CSIR (ZA); FULS PAUL FRITZ (ZA); JOUBERT ANDRE KEITH () 27 November 1997 see claim 1	1

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 June 1998	22/06/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	De Smet, F

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 98/00553

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	GB 944 993 A (RADYNE LTD.) 18 December 1963 see page 1, line 88 - page 2, line 6	1
A	US 3 943 318 A (HIRAI KAZUMI) 9 March 1976	
A	GB 1 114 938 A (HIRST (MICROWAVE HEATING) LTD.) 22 May 1968	
A	DE 89 00 624 U (N.V. PHILIPS' GLOEILAMPENFABRIEKEN) 23 March 1989	

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. .onal Application No
PCT/EP 98/00553

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2814708 A	26-11-1957	NONE	
US 3991295 A	09-11-1976	JP 988418 C	26-02-1980
		JP 50150042 A	01-12-1975
		JP 54021984 B	03-08-1979
		AU 8116375 A	18-11-1976
		CA 1032615 A	06-06-1978
		GB 1503002 A	08-03-1978
DE 1515149 A	14-08-1969	NONE	
WO 9744988 A	27-11-1997	AU 2914597 A	09-12-1997
		EP 0839435 A	06-05-1998
		AU 2914797 A	09-12-1997
		EP 0842025 A	20-05-1998
		WO 9744170 A	27-11-1997
GB 944993 A		NONE	
US 3943318 A	09-03-1976	AU 7865275 A	02-09-1976
		GB 1494522 A	07-12-1977
GB 1114938 A		NONE	
DE 8900624 U	23-03-1989	FR 2627259 A	18-08-1989